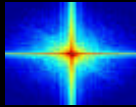


# Spectral Processing of Point-Sampled Geometry



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## Outline

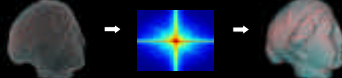
- Introduction
- Spectral processing pipeline
- Results
- Conclusions



Introduction

## Introduction

- Extend Fourier transform to 2-manifold surfaces



- ⇒ Spectral representation of point-based objects
- ⇒ Powerful methods for digital geometry processing



Introduction

## Applications

- Spectral filtering:
  - Noise removal
  - Microstructure analysis
  - Enhancement
- Adaptive resampling:
  - Complexity reduction
  - Continuous LOD



Introduction

## Fourier Transform

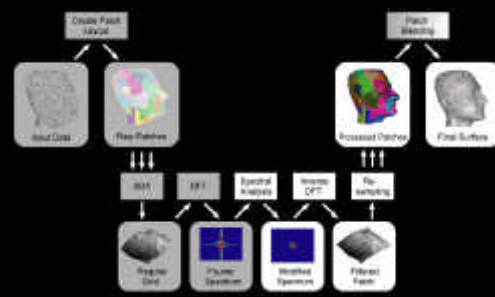
$$X_n = \sum_{k=1}^N x_k e^{-j2\pi \frac{nk}{N}}$$

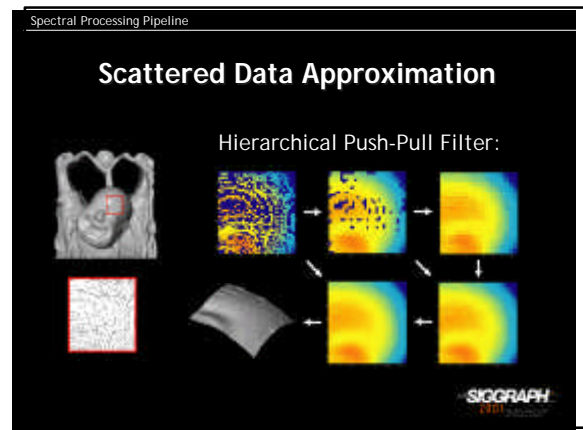
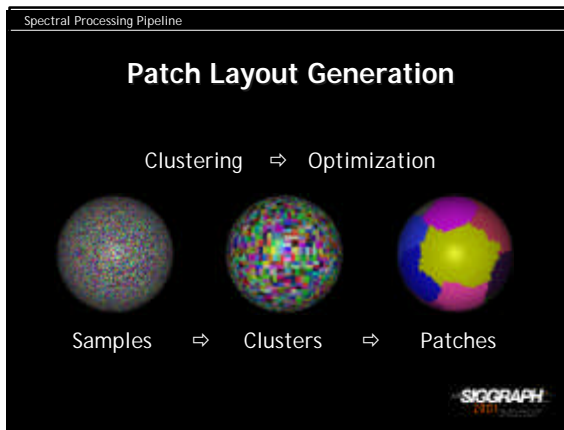
- Benefits:
  - Sound concept of frequency
  - Extensive theory
  - Fast algorithms
- Limitations:
  - Euclidean domain, global parameterization
  - Regular sampling
  - Lack of local control



Spectral Processing Pipeline

## Overview



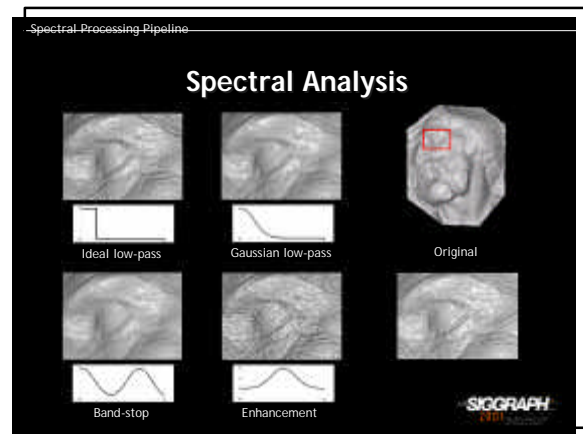


Spectral Processing Pipeline

## Spectral Analysis

- 2D Discrete Fourier Transform (DFT)
  - $\Rightarrow$  Direct manipulation of spectral coefficients
- Filtering as convolution:
 
$$F(x \otimes y) = F(x) \cdot F(y)$$
  - $\Rightarrow$  Convolution:  $O(N^2) \Rightarrow$  Multiplication:  $O(N)$
- Inverse Fourier Transform
  - $\Rightarrow$  Filtered patch surface

SIGGRAPH 2011



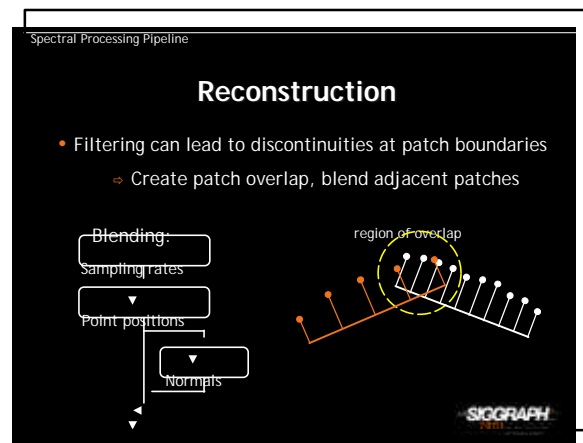
Spectral Processing Pipeline

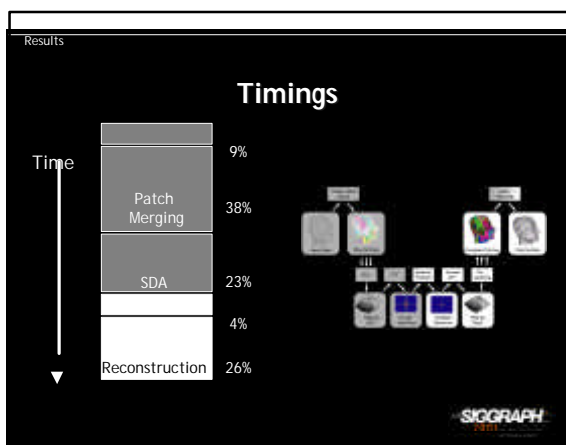
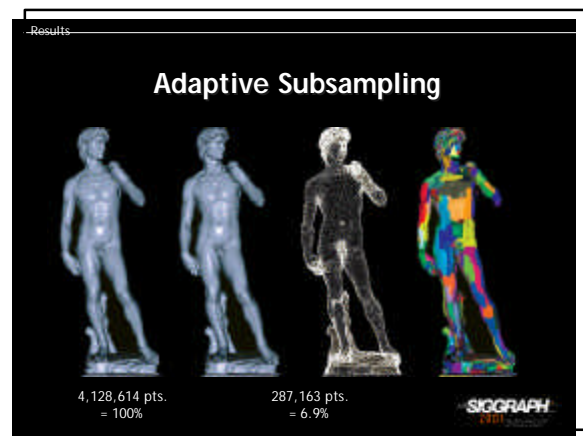
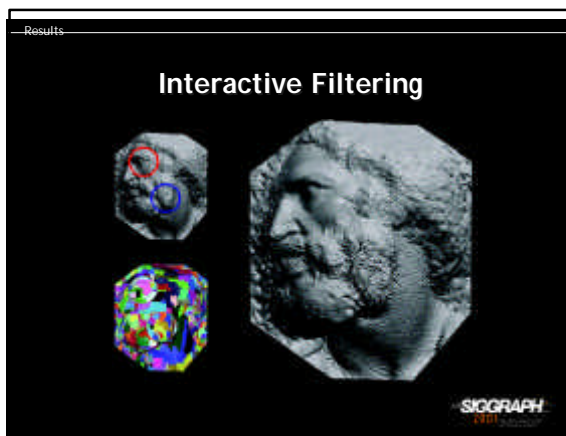
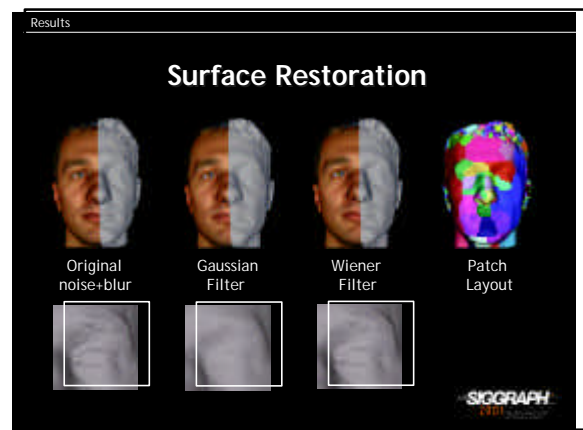
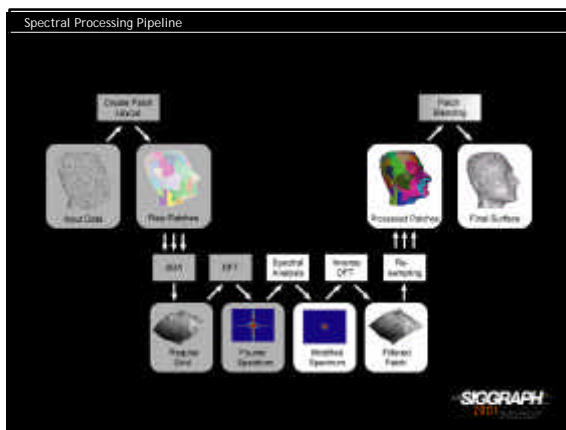
## Resampling

- Low-pass filtering
  - $\Rightarrow$  Band-limitation
- Regular Resampling
  - $\Rightarrow$  Optimal sampling rate (Sampling Theorem)
  - $\Rightarrow$  Error control (Parseval's Theorem)

Power Spectrum

SIGGRAPH 2011





### Timings

	Head	St. Matthew	David
#points	460,800	3,382,866	4,128,614
#patches	256	595	2,966
Preprocess	10.9	117.2	128.3
Total	15.8	153.0	189.6

SIGGRAPH 2009

## Summary

- Versatile spectral decomposition of point-based models
- Effective filtering
- Adaptive resampling
- Efficient processing of large point-sampled models



## Future Work

- Compression
  - ⇒ Scalar Representation + Spectral Compression
- Hierarchical Representation
  - ⇒ Modeling and Animation
- Feature Detection & Extraction
  - ⇒ Robust Computation of Laplacian



## Acknowledgements

Our Thanks to:

Marc Levoy and the Stanford Digital Michelangelo Project,  
Szymon Rusinkiewicz, Bernd Gartner,

